UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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MEMORANDUM

Subject: Upper Bound Excess lifetime cancer risk and remediation goals for the Arkwood Superfund site

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This memorandum calculated the upper bound excess lifetime cancer risk for dioxins and dibenzofurans, and calculated a risk-based remediation goal for the Arkwood Superfund site for carcinogenic polynuclear aromatic hydrocarbons (PAHs). This memorandum used scenarios and exposure parameters specified in the Arkwood Endangerment Assessment (August 30, 1989). This Endangerment Assessment was prepared using the Superfund Public Health Evaluation Manual (SPHEM), the current guidance at that time.

The dioxin risk calculation used the International Toxicity Equivalent Factors (ITEF) approach specified in the Habicht memo (March 21, 1990). The ITEF approach expressed the concentration of chlorinated dibenzo-p-dioxins and dibenzofurans in the form of 2,3,7,8-tetrachloro dibenzo-p-dioxin (2,3,7,8-TCDD) equivalents. The risk-based remediation goal for carcinogenic PAHs was calculated using the concept of benzo(a)pyrene (BaP) equivalents.

I. Calculation of Excess Cancer Risk

The upper bound excess lifetime cancer risk was calculated as the product of the contaminant-specific intake and the contaminant-specific slope factor. The chemical-specific intake was calculated as the sum of the exposure pathways (oral and dermal). The slope factor (SF) for 2,3,7,8-TCDD is 1.5E+5 (mg/kg-day)-1 (Integrated Risk Information System). The following algorithms are used to estimate the upper bound excess lifetime cancer risk:

$$Io = (C * Ai * Am * E * Ef * Cf * D) / (BW * AT)$$

$$Id = (C * Aa * Sa * Ab * Ef * Cf * E * D) / (BW * AT)$$

I = Io + Id

Risk = I * SF

Where:
- Ab = Dermal absorption factor (0.01)
- Ai = Soil Ingestion Rate
  - Adults and older children: 100 mg/event
  - Children (0 - 6 years): 200 mg/event
- Am = Soil matrix oral absorption factor (0.5)
- As = Surface are of skin exposed (hands) to soil
  - Adults: 910 cm2/event
  - Children (6 - 12 years): 625 cm2/event
  - Children (0 - 6 years): 500 cm2/event
- AT = Averaging time (25550 days)
- BW = Body weight
  - Adults: 70 kg
  - Children (6 - 12 years): 29 kg
  - Children (0 - 6 years): 16 kg
- C = Concentration of chemical in soil
- Cf = Conversion factor (1E-6 kg/mg)
- D = Exposure duration (years)
- E = Exposures events per year
- Ef = Soil exposure factor (0.5)
- I = Intake (mg/kg-day)
- Id = Intake from dermal route (mg/kg-day)
- Io = Intake from oral route (mg/kg-day)
- Sa = Soil adhering to skin (2 mg/cm2)
- SF = Chemical-specific slope factor (mg/kg-day)-1

Scenario I

Exposure Point: Railroad ditch
Population Exposed: Railroad personnel and Adults
Exposure Frequency (E): 6 events/year (Railroad personnel)
12 events/year (Adults)
Exposure Duration (D): 30 years (Railroad personnel)
58 years (Adults)
2,3,7,8-TCDD Equivalent
Concentration (C): 0.062 mg/kg (Grid RC)
Oral Intake:
- Railroad personnel - 1.6E-10 mg/kg-day
- Adults - 6.0E-10 mg/kg-day

Dermal Intake:
- Railroad personnel - 5.7E-11 mg/kg-day
- Adults - 2.2E-10 mg/kg-day

Total Intake:
- Railroad personnel - 2.2E-10 mg/kg-day
- Adults - 8.2E-10 mg/kg-day

Excess cancer risk attributed to 2,3,7,8-TCDD equivalents:
- Railroad personnel - 3.3E-5
- Adults - 1.2E-4

Total excess cancer risk (including carcinogenic PAHs):
- Railroad personnel - 3 in 100,000 (3E-5)
- Adults - 1 in 10,000 (1E-4)

Scenario II

Exposure Point:	Main site	
Population Exposed:	Adults and children 6 - 12 years	
Exposure Frequency (E):	12 events/year (Adults)	
	6 events/year (Children 6 - 12)	
Exposure Duration (D):	58 years (Adults)	
	6 years (Children 6 - 12 years)	
	Grid B	Grid TC
2,3,7,8-TCDD Equivalent Concentration (C):	0.018 mg/kg	0.010 mg/kg
Oral Intake:		
Adults	1.8E-10 mg/kg-day	1.0E-10 mg/kg-day
Children	4.4E-11 mg/kg-day	2.4E-11 mg/kg-day
Dermal Intake:		
Adults	6.4E-11 mg/kg-day	3.6E-11 mg/kg-day
Children	5.4E-12 mg/kg-day	3.0E-12 mg/kg-day
Total Intake:		
Combined ages	2.9E-10 mg/kg-day	1.6E-10 mg/kg-day
Excess cancer risk attributed to 2,3,7,8-TCDD equivalents:		
Combined ages	4.4E-5	2.4E-5

Total excess cancer risk (including carcinogenic PAHs):
Adults and children - 8 in 10,000 (8E-5)

Scenario III

Exposure Point:	Main site	
Population Exposed:	Adults, children 6 - 12 years and children 0 - 6 years	
Exposure Frequency (E):	365 events/year (All ages)	
Exposure Duration (D):	58 years (Adults)	
	6 years (Children 6 - 12 years)	
	6 years (Children 0 - 6 years)	
	Grid B	Grid TC
2,3,7,8-TCDD Equivalent Concentration (C):	0.018 mg/kg	0.010 mg/kg
Oral Intake:		
Adults	5.5E-09 mg/kg-day	3.1E-09 mg/kg-day
Children (6 - 12)	1.4E-09 mg/kg-day	7.8E-10 mg/kg-day
Children (0 - 6)	4.8E-09 mg/kg/day	2.7E-09 mg/kg-day
Dermal Intake:		
Adults	1.9E-09 mg/kg-day	1.1E-09 mg/kg-day
Children (6 - 12)	3.3E-10 mg/kg-day	1.8E-10 mg/kg-day
Children (0 - 6)	4.8E-10 mg/kg/day	2.7E-10 mg/kg-day
Total Intake:		
Combined ages	1.5E-08 mg/kg-day	8.1E-09 mg/kg-day
Excess cancer risk attributed to 2,3,7,8-TCDD equivalents:		
Combined ages	2.2E-3	1.2E-3

Total excess cancer risk (including carcinogenic PAHs)
Combined ages - 4 in 1,000 (4E-3)

II. Recommendation of Remedial Action Levels

The most likely future land use for the Arkwood Superfund site is industial (Bondy memo, July 2, 1990). This land use was used in determining the remediation goals for the site.

Dioxins and Dibenzofurans

In the Johnson letter (July 30, 1987), the Agency for Toxic Substances and Disease Registry (ATSDR) discussed a remediation goal for 2,3,7,8-TCDD at other Superfund sites with industrial land use of 20 ug/kg (ppb) (Attachment 1). The remediation goal of 20 ug/kg has been used at other Superfund sites with industrial land use across the United States. This remediation goal appears to be applicable to the Arkwood Superfund site since the most likely future land use is industrial. If all surface soils greater than 20 ug/kg 2,3,7,8-TCDD equivalents were remediated, this remedy probably would result in an overall site average much lower than target level of 20 ug/kg 2,3,7,8-TCDD equivalents.

Polynuclear Aromatic Hydrocarbons

The remediation goal for carcinogenic PAHs is expressed in equivalents of BaP. BaP is one of the most carcinogenic PAHs and serves as the bench mark for the other carcinogenic PAHs. The slope factor for BaP is 11.5 (mg/kg/day)-1 (SPHEM). The following algorithm is used to calculate a risk-based remediation goal for carcinogenic PAHs:

$$\text{Goal} = \frac{\text{Target Risk (e.g., 1E-6)} * BW * AT}{Cf * D * E * Ef * SF\ (Ai * Am + As * Sa * Ab)}$$

Where:

- Ab = Dermal absorption factor (0.01)
- Ai = Soil Ingestion Rate
  - Adult: 100 mg/event
- Am = Soil matrix oral absorption factor (0.5)
- As = Surface are of skin exposed (hands) to soil
  - Adult: 910 cm2/event
- AT = Averaging time (25550 days)
- BW = Body weight
  - Adult: 70 kg
- Cf = Conversion factor (1E-6 kg/mg)
- D = Exposure duration (30 years)
- E = Exposures events per year (260 events/year)
- Ef = Soil exposure factor (0.5)
- Sa = Soil adhering to skin (2 mg/cm2)
- SF = Slope factor for BaP (11.5 mg/kg-day)-1

The 1E-6, 1E-5 and 1E-4 risk-based remediation goals for carcinogenic PAHs (expressed as BaP equivalents) are 0.6, 6.0 and 60 mg/kg, respectively.